Solar Power for Monitoring and Evaluation

Presentation by Jeff Crystal
COO, Voltaic Systems
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Agenda

• Energy Budget – Calculate your Group Power Consumption
• Practical Solar – Solar Power under Different Conditions
• Power – Centralized or Distributed
• Design – Choose a Panel
• Design – Choose a Battery
• Final Thoughts
Energy Budget
Calculate your Personal Power Consumption (per day)
Step 1:
Determine battery capacity of device in Watt hours

For Android Devices:

For Apple Devices:

<table>
<thead>
<tr>
<th>Phone*</th>
<th>mAh</th>
<th>Estimated Watt hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>iPhone 4</td>
<td>1400</td>
<td>5</td>
</tr>
<tr>
<td>iPhone 5</td>
<td>1440</td>
<td>5</td>
</tr>
<tr>
<td>iPhone 6</td>
<td>1810</td>
<td>7</td>
</tr>
<tr>
<td>iPhone 6 Plus</td>
<td>2915</td>
<td>11</td>
</tr>
</tbody>
</table>

*All are 3.7V
Step 2:
Multiply battery capacity by change in battery percentage

Start of Use:

End of Use:

Formula:

\[(0.81 - 0.07) \times \frac{5}{3.7} \]

% change in battery capacity
Watt hours of device’s battery
Watt hours used
## Energy Budget:

### Example

Add up all your devices:

<table>
<thead>
<tr>
<th>Device</th>
<th>Battery Capacity (mah)</th>
<th>Battery Voltage (V)</th>
<th>Battery Capacity (Watt Hours)</th>
<th>Use per Day (% of Full Charge)</th>
<th>Watt hours per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>HTC Phone 1</td>
<td>1900</td>
<td>3.7</td>
<td>7 Watt Hours</td>
<td>100%</td>
<td>7</td>
</tr>
<tr>
<td>HTC Phone 2</td>
<td>1900</td>
<td>3.7</td>
<td>7 Watt Hours</td>
<td>100%</td>
<td>7</td>
</tr>
<tr>
<td>iPad Mini</td>
<td>6800</td>
<td>3.7</td>
<td>25 Watt Hours</td>
<td>50%</td>
<td>12.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>26.5 Watt Hours</strong></td>
</tr>
</tbody>
</table>
Reduce Your Energy Budget

- Reduce screen brightness
- Turn on airplane mode
- Turn off GPS when not in use
- Turn your device off at night
- Reduce screen timeout
Devices without Batteries

Determine Wattage:
- Look at Specs or Power Supply

Formula:

\[
\text{Device Wattage} \times \text{Hours of use/day} = \text{Watt hours}
\]

\[
20 \times 8 = 160
\]

- Device Wattage
- Hours of use/day
- Watt hours
• Do a basic calculation to determine your energy needs
• Energy is measured in Watt hours
• Small devices generally use less power than larger devices:

Watt Hours = Watts x Number of Hours Used
Practical Solar
Solar Power Under Different Conditions
Practical Solar:
Typical Set Up

- Place the solar panel outside and point to the sun
- Panel charges the external battery
- Plug your device into the external battery for regulated power when you need it
Ideal Solar Charging Conditions:
- Panel pointed at the sun at a 90° angle
- Direct sun (no clouds)
- No shade on the panel
- Ideal temperature of 25°C Celsius
In good conditions, $\frac{1}{2}$ of rated power of panel will make it into device.

**Example:**

18 Watt hour tablet

6 Watt solar panel

\[
\text{Device Wattage/Panel Wattage} = \frac{18}{6} \times 2 = 6 \\
\text{Hours to charge} = 6
\]
Practical Solar:
Real Conditions

- Hazy: $-20\%$
- Heavy Clouds: Up to $-90\%$
- Shaded: Up to $-95\%$
- 15 Degree: $-5\%$
- 45 Degree: $-30\%$
- 90 Degree: $-95\%$
Practical Solar: Real Conditions

On a mixed day (sun + clouds), maybe $\frac{1}{4}$ of rated power of the panel will make it into the device

Example:

18 Watt hour tablet

\[ \frac{18}{6} \times 4 \]

Device Wattage/Panel Wattage

Standard ‘Loss’ Variable

12 Hours to charge
Design:
Choose a Solar Panel & Battery
Centralized vs. Distributed

Centralized:
- Large (non-portable) solar panel & large battery bank

Distributed
- Many small (portable) solar panels and batteries
Design:
Choose a Panel Size

About 1 Full Charge Per Day

2 Watts
3.5 Watts
6 Watts
9 Watts
17 Watts

Feature Phone
Smartphone
7” Tablet
10” Tablet
Laptop
### Design: Panel Math

- **50% of Rated Power Gets Through Battery and into Device in Good Conditions**

**EXAMPLE:** A 2 Watt panel will produce 1.4 Watts in Full Sun, but only 1 Watt will get to Device from Battery

### To determine your Minimum Panel Size to Charge in a Single Day:

<table>
<thead>
<tr>
<th>Formula</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>((11.1 / 5))</td>
<td>Total Energy Budget (Watt hours) / Hours of Sun per Day</td>
</tr>
<tr>
<td>(\times 2)</td>
<td>Standard ‘Loss’ Variable</td>
</tr>
<tr>
<td><strong>4.5</strong></td>
<td>Minimum Panel Size (Watts)</td>
</tr>
</tbody>
</table>

### Minimum Panel Size on a ‘So-So’ Day:

<table>
<thead>
<tr>
<th>Formula</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>((11.1 / 5))</td>
<td>Standard ‘Loss’ Variable Increases</td>
</tr>
<tr>
<td>(\times 4)</td>
<td></td>
</tr>
<tr>
<td><strong>8.9</strong></td>
<td>Watts Minimum</td>
</tr>
</tbody>
</table>
## Design:
Choose a Panel Type

<table>
<thead>
<tr>
<th>Panel Type</th>
<th>Monocrystalline</th>
<th>Monocrystalline</th>
<th>CIGS / Amorphous</th>
<th>Mono / Polycrystalline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rigid – Urethane</td>
<td>Compact and Rugged</td>
<td>Easily Packable</td>
<td>Slightly better performance in cloudy conditions</td>
<td>Low $/ Watt on larger systems</td>
</tr>
<tr>
<td></td>
<td>Shorter lifespan than glass or urethane</td>
<td>Larger surface area</td>
<td>Not very portable</td>
<td></td>
</tr>
</tbody>
</table>
Solar Panels = Power Production

Batteries = Power Storage and Regulation
Design:
Battery Voltages in DC

5 Volt (USB):

- Smartphone
- 7” Tablets
- 10” Tablets

12, 16, 19 Volt:

- DSLR Camera
- Laptops
Design:
Choose a Battery

15 Watt Hours
4,000 mAh
- Smartphone
- Light

44 Watt Hours
12,000 mAh
- Smartphone
- Tablet

72 Watt Hours
20,000 mAh
- Smartphone
- Tablet
- Laptop
- Efficient Desktops (Aleutia – DC)

1200 Watt Hours
- Traditional Desktops (AC)
- Small Appliances

1200 Watt Hours
- Traditional Desktops
- Small Appliance
Design:
Battery Math

- 70% of Rated Capacity Gets into Device
  
  EXAMPLE: A 100 Watt hour battery will deliver 70 Watt hours into your device

To determine your Group’s battery size to charge every device 1X:

\[
\frac{\text{Total Watt hours}}{0.7}
\]

To determine your Group’s battery size to charge every device 2X:

\[
\frac{(\text{Total Watt hours}) \times 2}{0.7}
\]
Final Thoughts

- Understand how much power you need
- Be realistic about how much power you can produce
- Get a system that exceeds your demands if possible
- Take time to train your team how to maximize power production